A Novel Camera Type for Very High Energy Gamma-Astronomy

Thomas Krähenbühl for the FACT project

Institute for Particle Physics
ETH Zurich, Switzerland

Gemeinsame Jahrestagung
SPS/ÖPG/ÖGAA

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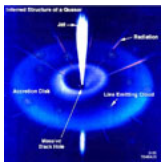
ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

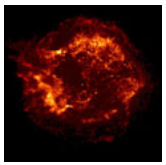
Overview

1. Very High Energy Gamma-Astronomy
   - What is VHE γ-astronomy?
   - Camera Requirements
2. A Novel Photodetector: G-APDs
   - Basic Properties
   - Challenges
3. The FACT Project
   - The Prototype Module M0
   - First Measurements
   - Outlook: A Camera For The DWARF Telescope

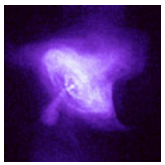
What is VHE γ-astronomy?

Some galactic sources like supernova remnants, pulsar wind nebulae and binaries as well as some classes of active galactic nuclei emit photons in the very high energy range (some GeV to some tens of TeV).


AGN

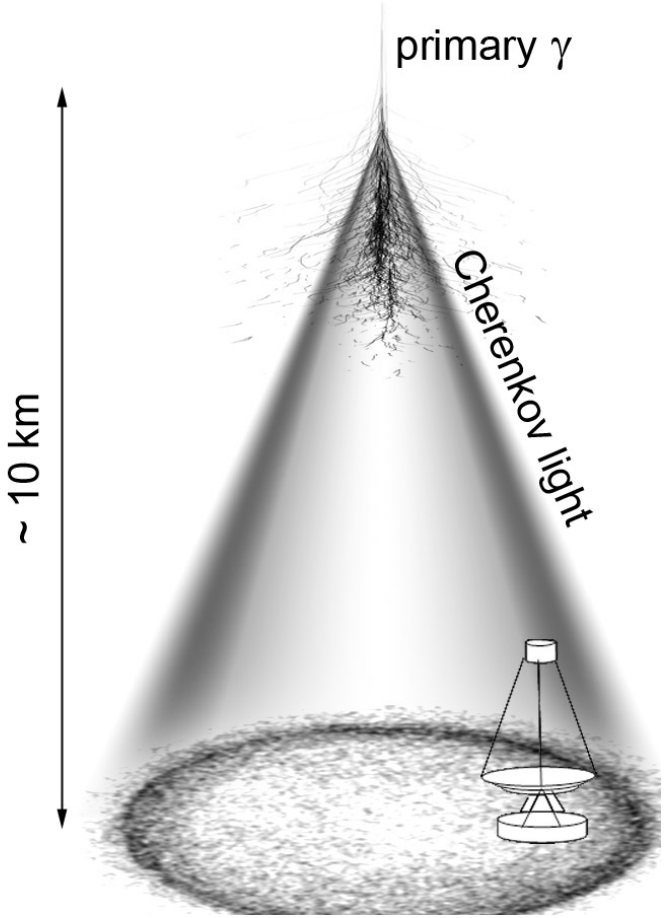

SNR


GRB


Pulsars

Indirect measurement of these photons:

- The primary γ produce air showers when entering the atmosphere.
- Secondary particles emit Cherenkov light.
- Imaging air Cherenkov telescopes (IACT) within the light cone detect the Cherenkov light.



Camera Requirements

Sensitivity: very few photons, eg. for $E_\gamma \approx 1\ TeV$: 100 photons/m^2.

Speed: very short flashes of a few nanoseconds.

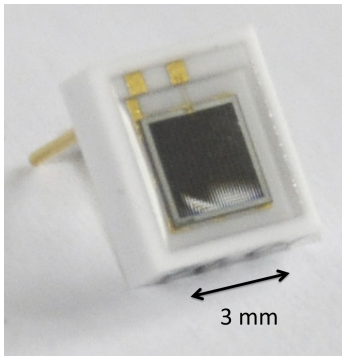
Ruggedness: operation under outdoor conditions with high night sky background and temperature variations.

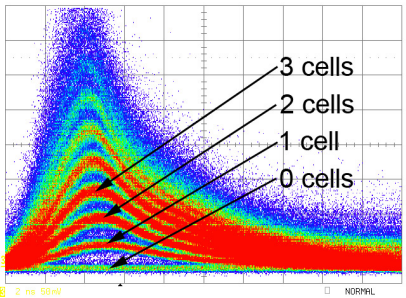
Ease of use: homogeneity, accidental triggers...

Today's IACTs (eg. MAGIC, HESS, Veritas...) use cameras based on photomultiplier tubes, which leaves room for improvements.

Basic Properties of G-APDs

Geiger-mode Avalanche Photodetectors (G-APDs or SiPM, MPPC, PPD...)

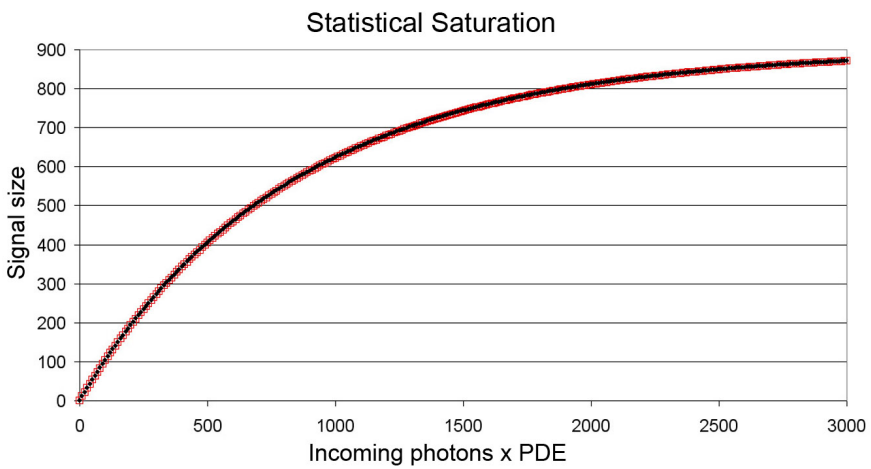


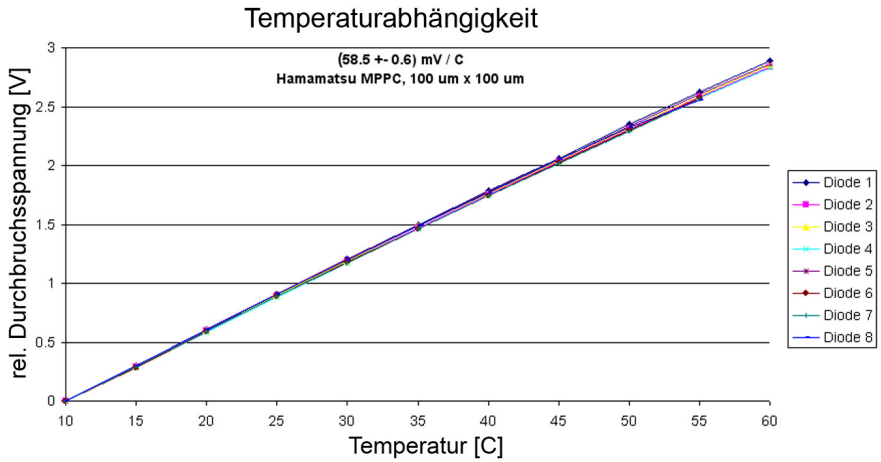


- are semiconductor photosensors
- are divided into cells: each cell can detect single photons, the total signal is the sum of the identical single cell signals
- are very sensitive: photon detection efficiency 30 %-50 %
- have a gain of $10^5 - 10^7$
- operate at low bias voltages $< 100\ V$
- are tolerant to bright light
- show no aging
- are being intensively researched and developed (dedicated conferences, many manufacturers...)

Challenges

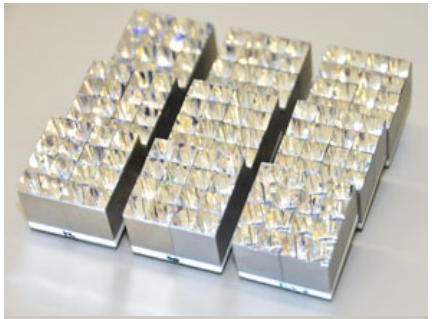
- Pixelization causes statistical saturation
- Crosstalk: a single initially fired cell can trigger neighbouring cells
- These two effects have to be corrected, but still induce noise. Nonetheless: excess noise factor < 1.1 possible.
- Almost all operational parameters are temperature dependent.



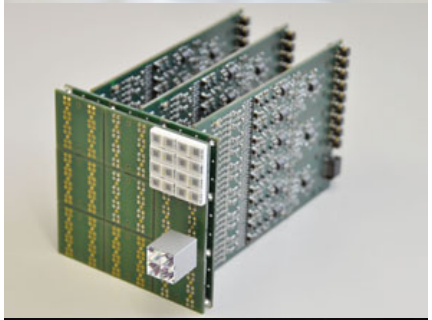


The Prototype Module M0

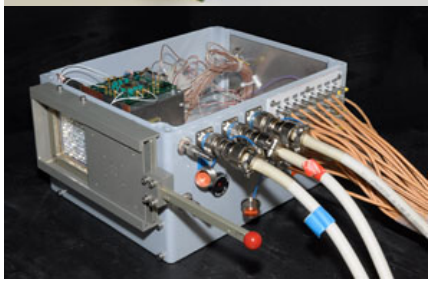
The First G-APD Camera Test (FACT) project aims at building a IACT camera based on G-APDs.



Light collectors (so-called Winston cones) are used to concentrate the incoming light onto the sensitive area of the G-APDs.



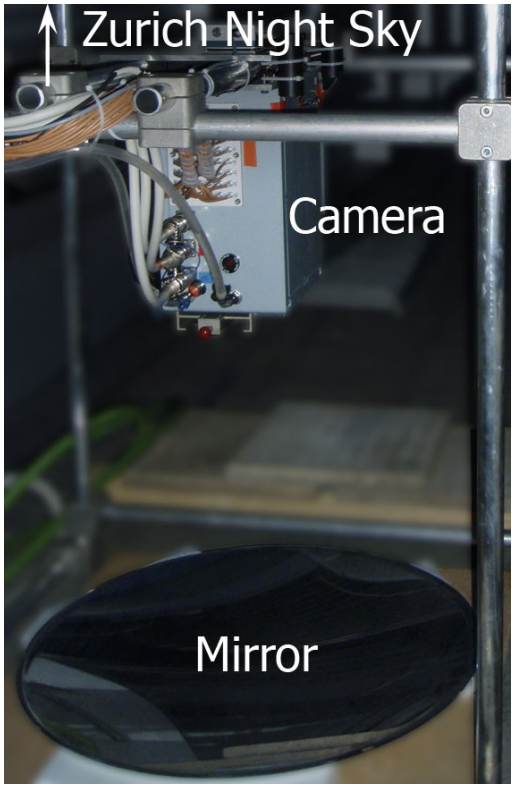
The G-APDs are attached to preamplifier boards, which also distribute the bias voltage.



The camera box includes a cooling system and is weatherproof.

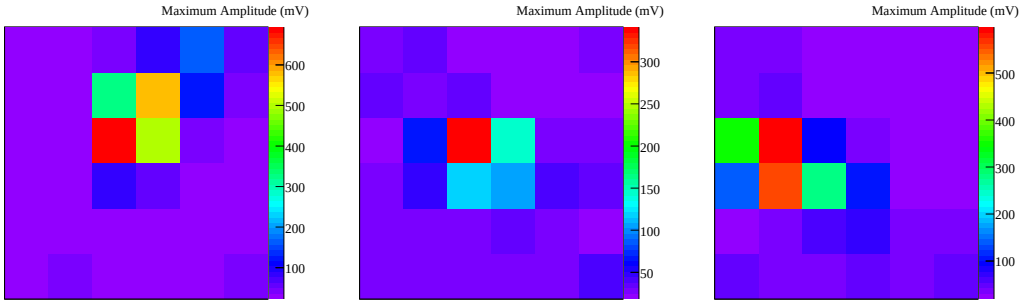
The cooling system is not necessary for the operation of the camera but is used for testing purposes.

First Measurements



- The prototype camera has been installed in the focal plane of a mirror with 80 cm focal length (1° f.o.v. per pixel).
- Measurement with very high NSB under changing weather conditions.

⇒ First shower pictures of a camera based on G-APDs. A similar project exists at the MPI Munich.



Outlook: A Camera For The DWARF Telescope

- Extended testing of the operational parameters of the prototype camera
  - changing temperatures
  - changing NSB
- In parallel: development of a camera for the DWARF telescope
  - $3 - 5^{\circ}$ f.o.v.
  - integrated readout electronics using the DRS4 chip

- DWARF telescope: Dedicated multiWavelength AGN Research Facility
  - situated at La Palma, Canary Islands
  - a refurbished telescope from the HEGRA experiment
  - intended for the long-term monitoring of a few selected sources